Space Weather Technical Forecast

Issued on Wednesday, 15 May 2024 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of X-flares day 1 (15 May), but soon declining with AR3664 receding onto the far-side. Ongoing S1 Minor Solar Radiation Storm. Slight chance G1 Minor Storm day 1-2 (15-16 May).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with three X-class flares observed from AR3664 now over the southwest limb. This included an X8.7 at 14/1651 UTC, the largest flare of the solar cycle so far, along with an X1.7 at 14/0209 UTC and an X1.2 at 14/1255 UTC. Significant magnetic looping remains visible above the region in SDO imagery, and indicates the potential for further strong flares to be visible despite its far-side location. There are twelve sunspot regions on the visible disc, however they are all small and simple, with the only notable growth observed in AR3670, a small bipolar region in the northwest and a new emergent spot near the south-centre disc. Of the visible regions AR3680 was the most active with a nearby filament eruption producing a long period M4.4 flare.

The X-flares and M4.4 flares all produced CMEs, however none of these are Earth-directed. A filament eruption was also observed off the northeast disc at 14/1000 UTC, with a complex CME observed. This has been assessed as likely missing, north and behind Earth, but a glancing interaction late day 3 or early day 4 (17-18 May) cannot be ruled out.

Solar Wind / Geomagnetic Activity: The tail-end of the recent CME enhanced solar wind continued, with elevated speeds of 550km/s observed at L1 by DSCOVR. Density remained near average. Total Interplanetary Magnetic Field (IMF), Bt, was initially Moderate at 7nT, but soon became Weak, easing to 3-6nT by 14/0600 UTC. The north-south component Bz was generally weak and positive (northward), with only brief negative (southward) spells, ranging +6 nT to -4 nT. Phi angle was initially negative (towards the Sun) but became positive (away from the Sun) from 14/0600 UTC. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10 MeV) by GOES-18 has been at S1 Minor Radiation Storm level throughout, with a brief period of S2 Moderate Radiation Storm 14/0340-0650 UTC peaking 121 pfu at 14/0505 UTC. Observed proton flux has subsequently slowly declined. High energy electron flux (greater than 2MeV) observed by GOES16 was at Moderate levels, reaching 988 pfu at 14/1740 UTC. The associated 24-hour fluence was well the Active threshold but on a rising trend, with an observed fluence at 15/0000 UTC of 5.19e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is likely to continue day 1 (15 May) with the potential for further flaring from AR3664 to be visible. Activity then declining to Low with a chance of increasing to Moderate with isolated M-flares from the smaller and simple regions currently on the visible disc.

Solar Wind / Geomagnetic Activity: There are two CMEs that are currently expected to largely miss Earth, but have some potential for glancing interactions. The first is from the long duration M6.6 flare of AR3664 on 13 May, perhaps glancing later day 1 or early day 2 (15-16 May). The

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second from the filament eruption on the north-east disc on 14 May, perhaps arriving late day 3 or early day 4 (17-18 May). Both of these are low confidence. Otherwise, no other sources of enhancement are expected with current elevated solar winds expected to gradually ease. Mainly Quiet activity is expected with Unsettled intervals, but with the potential for Unsettled to Active spells with a chance of G1 Minor Storm intervals from any CME glances.

Energetic Particles / Solar Radiation: GOES-18 proton flux is expected to continue easing likely falling below the S1 level day 2 (16 May), but still with the potential for enhancements from any further significant flares from AR3664, as the protons can still be directed towards Earth along the Parker Spiral. This potential gradually declining as the sunspot moves further onto the far-side. High energy electron flux is forecast to also rise as solar winds ease, with any charging that has occurred at lower orbits expanding out to GEO. This brings a likelihood of High electron flux during the forecast period, along with a chance of Active electron fluence.

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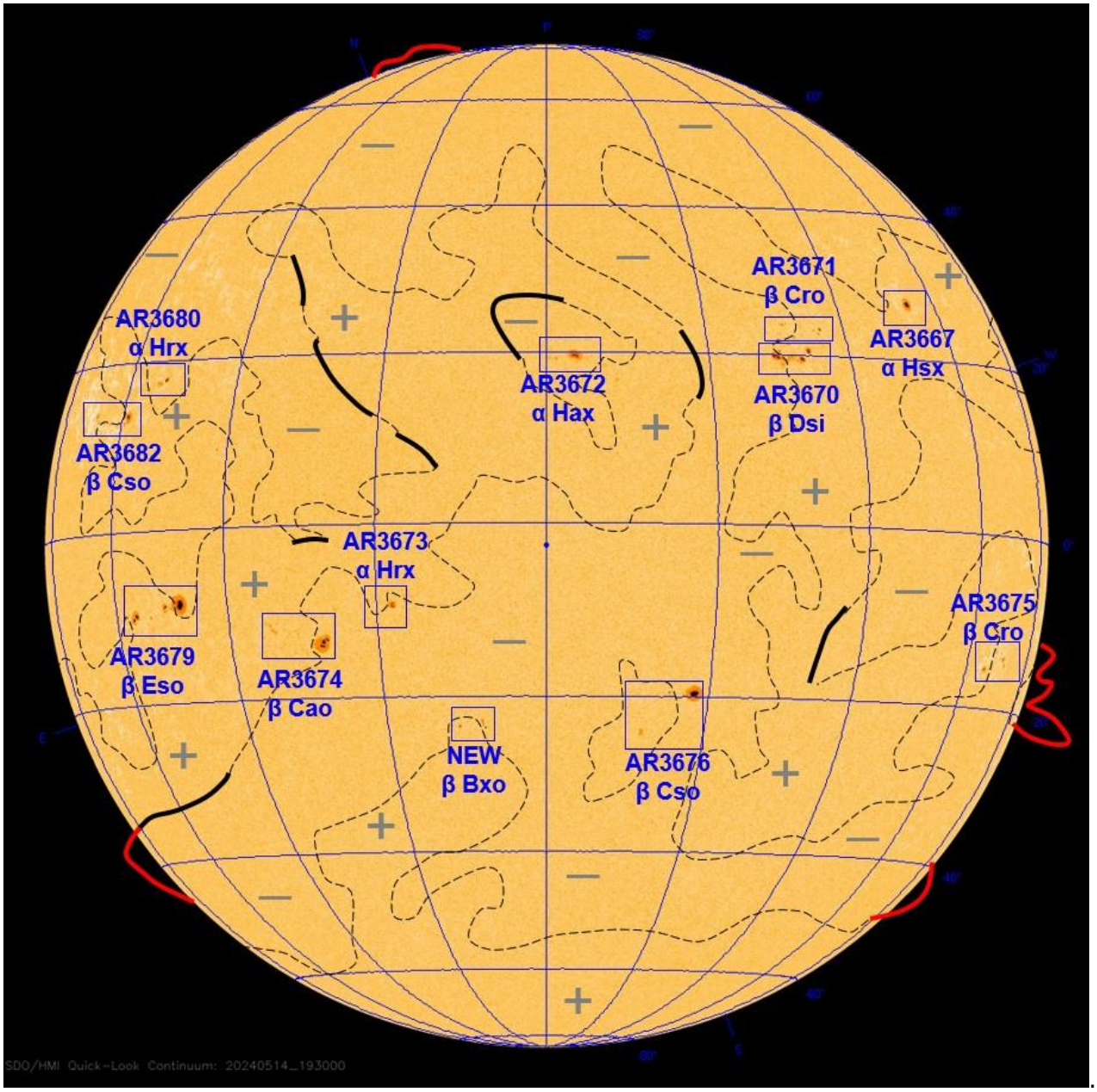
Figure 1. Solar Analysis Valid 14/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs that are currently expected to largely miss, however there is some potential for glancing impacts at Earth.

These first is from the long period M6.6 flare of AR3664 on the SW limb on 13 May. This produced a wide flare with a broad shock, and while the majority of the material is expected to miss, passage of the shock of this feature is possible later day 1 or early day 2 (15-16 May). The second is from a filament eruption in the northeast disc on 14 May. This largely passes north and behind Earth, but glancing interactions cannot be completely ruled out late on day 3 or day 4 (17-18 May).

Otherwise current solar winds, still elevated after the numerous CME arrivals over the last 3-4 days, are expected to gradually ease back towards background slow wind conditions, with no coronal holes on the Earth-facing disc. Mainly Quiet activity is expected with Unsettled intervals. Any CME glances will bring the potential for Unsettled to Active spells with a chance of G1 Minor Storm intervals, however these are low confidence.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
13/1202	Partial halo shock	LD M6.6 from AR3664	SW Limb	1350 km/s	Late 15/early 16 May	Likely missing, but chance of glancing or shock impacts
14/1526	Nil	Filament eruption	NE disc	685 km/s	Late 17/early 18 May	Likely missing, but small chance of glancing

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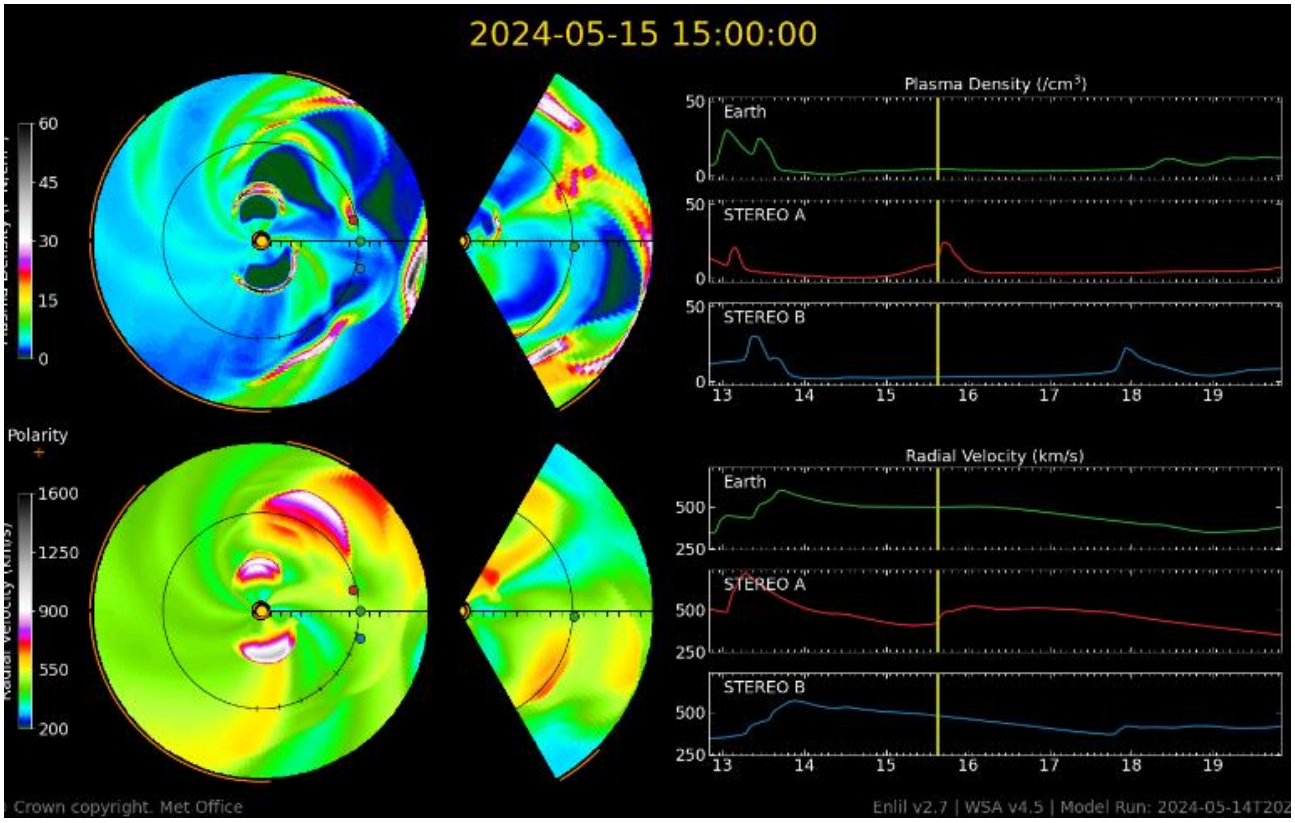
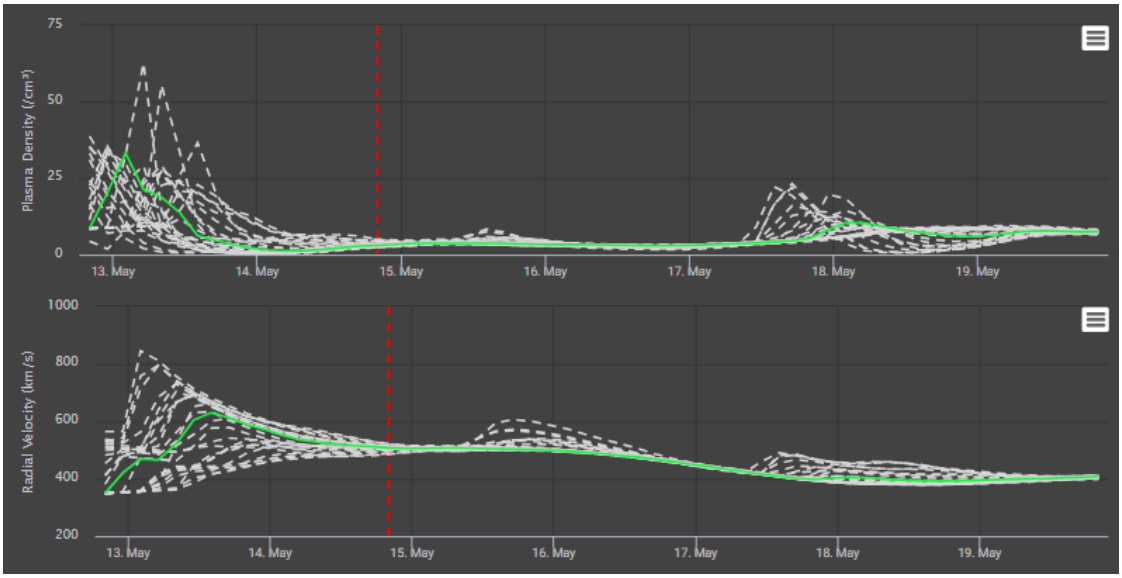
Figure 2: Enlil and ensemble (showing chance of glance on 15 May)





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Radio Blackouts - X-Ray Flares:

Activity is expected to remain High to Moderate day 1(14 May), with further M-flares expected, and a likelihood of isolated X-flares, before declining to mainly Low to Moderate, with a chance of isolated M-flares day 2 (15 May) onward.

The main flare risk continues to be from AR3664 despite its location over the southwest limb, with significant magnetic looping still evident in SDO imagery over the southwest limb, giving the potential for significant flares to be observed.

Across the visible portion of the disc, there are currently twelve sunspot regions, however these are all small and magnetically simple, with very little sign of growth or development. Some weak flux emergence was observed in AR3670 in the northwest disc, and with a new small sunspot development near the south-centre disc. A long period M-flare was also observed from near AR3682, however this spot remains simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	50	40	40
Very Active	R3 to R5 X Class	Yes	50	10	1	1

Figure 3a: GOES-16/18 X-ray flux

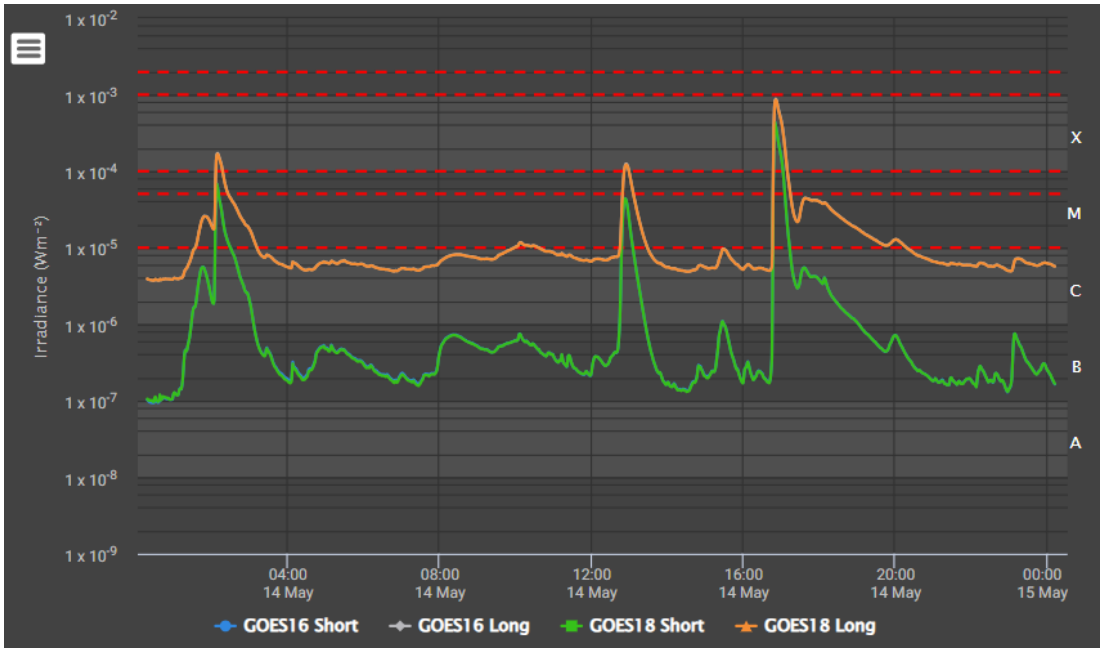

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Figure 3b: The three observed X-flares from AR3664 (X1.5/X1.2/X8.7)

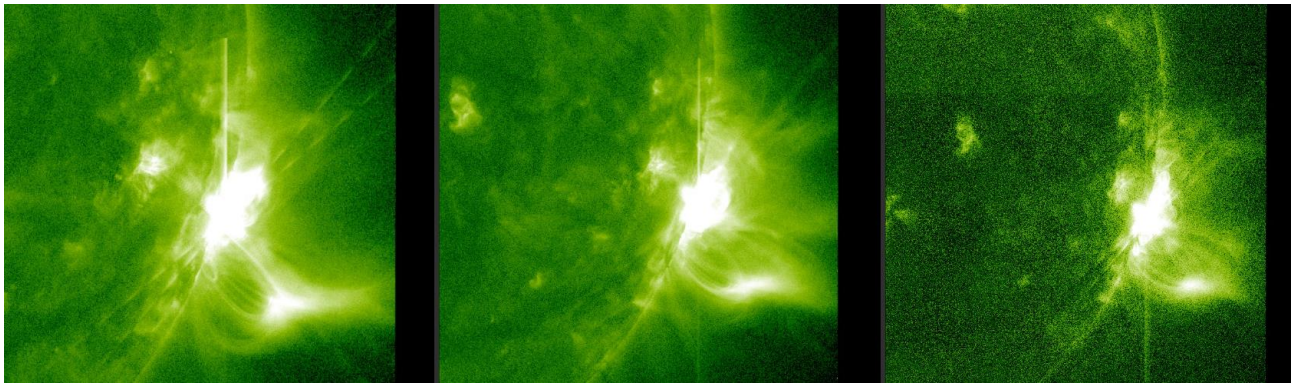
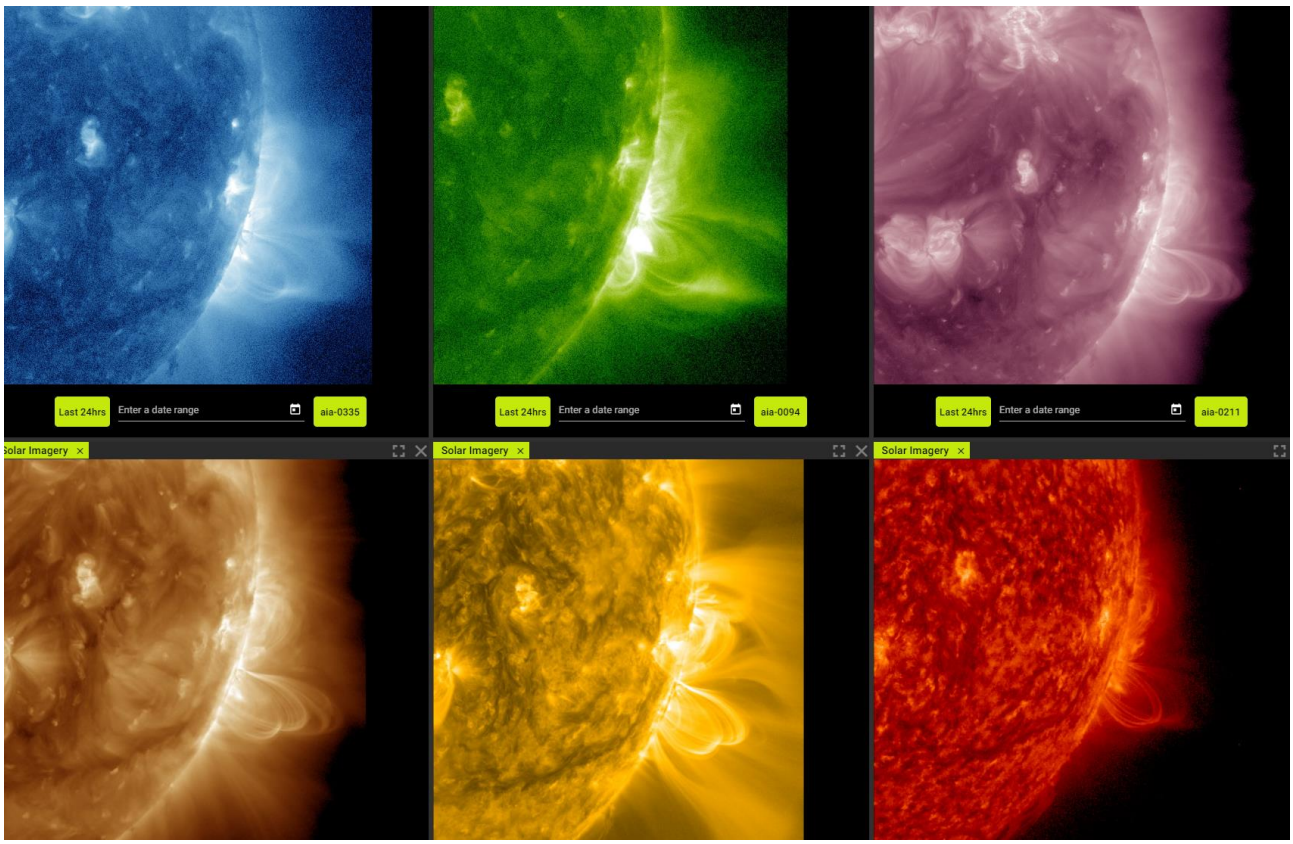


Figure 3c: SDO imagery of magnetic looping still visible over SW limb



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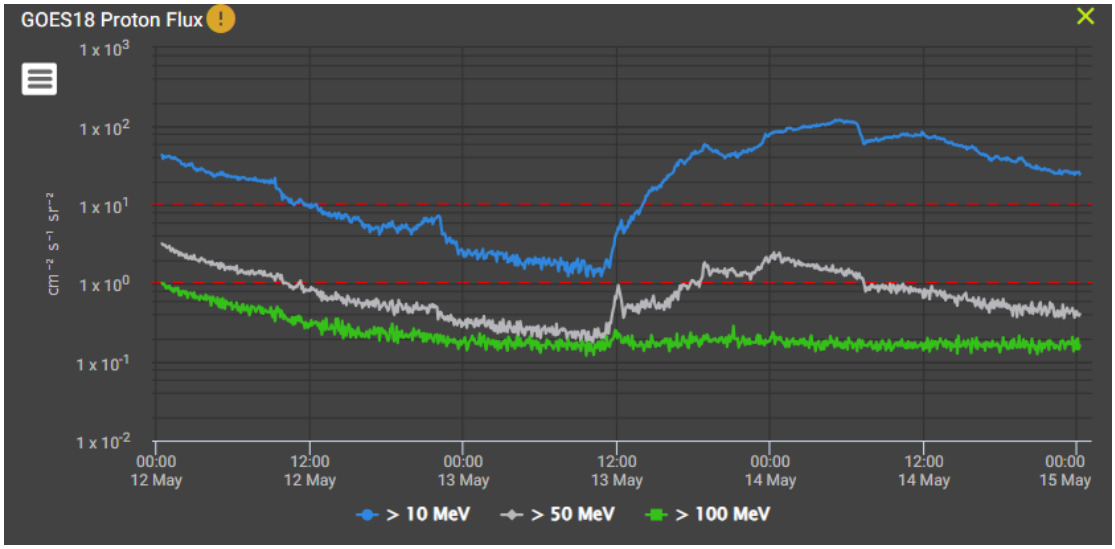
Solar Radiation Storms - (High Energy Protons):

Enhancement to the proton flux, as observed by GEO, is ongoing after the M6.6 flare of AR3664 on the southwest limb on 13 May, with some contribution also possible from the X-flares that occurred from this region from over the limb on 14 May.

Flux is likely to gradually decline, perhaps more notably with any passing CME glances that may occur with none of the spots on the visible disc currently expected to give a notable risk of further enhancement. However, further increases to the observed flux cannot be ruled out from any further significant flares from AR3664 over the southwest limb, as these can be directed back towards Earth along the Park Spiral. This risk fading day 3 onward (17 May).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	60	30	10
Very Active	**≥ S3 ***	No	5	5	5	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 >10MeV Proton Flux over the last 72 hours



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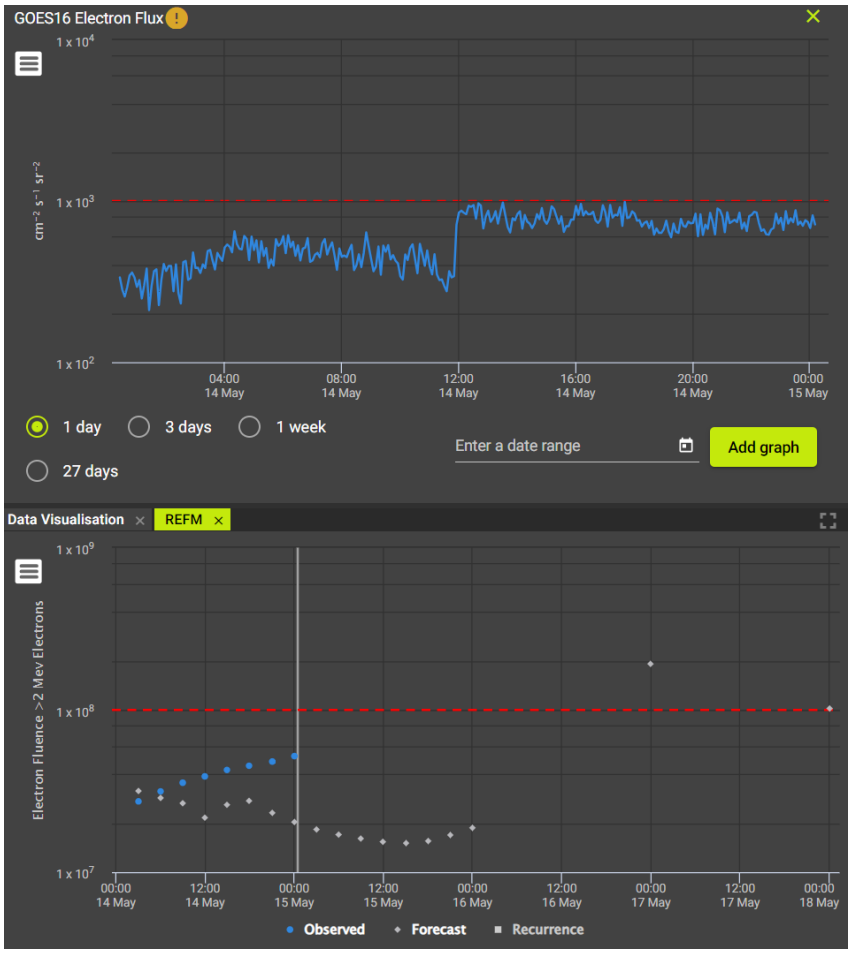
High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16 is currently at Moderate levels, but is likely to see an increasing trend during the period as solar winds ease. The CME arrivals over the previous days have likely resulted in a charging at lower orbits, and as the Van Allen belts ease back towards GEO through days 1-2 (15-16 May), this charging has the potential to bring periods of High electron perhaps becoming persistently High. Confidence is Low however.

The associated 24 fluence will subsequently respond with a gradual rising trend, with a likelihood of reaching Active day 2 (16 May). MOSWOC REFM is perhaps underdoing the initial gradual rise, but does show Active fluence by day 2, which agrees with current expectations.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	60	60	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES 16 Electron flux (top) and fluence with REFM (bottom)



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